(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 077 582 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.02.2001 Bulletin 2001/08

(51) Int Cl.7: **H04Q 7/38**

(21) Application number: **99402029.5**

(22) Date of filing: **10.08.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **MOTOROLA, INC.**
Schaumburg, IL 60196 (US)

(72) Inventors:
- **Faure, Cecile**
  75005 Paris (FR)
- **Boscovic, Dragan**
  78100 St. Germain en Laye (FR)
- **Benamar, Abdelkrim**
  77177 Brou sur Chatereine (FR)

(74) Representative: **Kopacz, William James**
83, Avenue Foch
75116 Paris (FR)

(54) Method to reduce interference between mobiles using different duplex technology

(57) A method for reducing interference between a mobile station (10) operating in time division duplex mode and a mobile station (12) operating; in frequency division duplex mode comprising, scanning (40) available frequency division duplex frequencies for a handover (46) to a frequency division duplex system. If a frequency division duplex frequency is available, a handover is initiated to the frequency division duplex system. If no frequency division duplex frequency is available, time division duplex frequencies more remote from the interfered with frequency division duplex frequency are scanned (48). If a more remote time division duplex frequency is available, a handover to the more remote time division duplex system is initiated. (50).

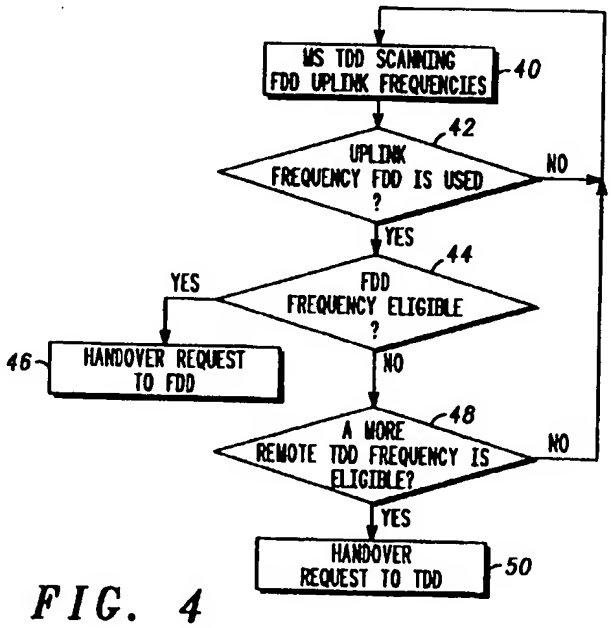

FIG. 4

EP 1 077 582 A1

Description

Field of the Invention

[0001] This invention relates to radio communications systems and more particularly to the reduction of interference in mobile radio communication; systems.

Background of the Invention

[0002] Cellular radio communication systems are well known. Such systems are, typically, comprised of a number of cells, each having a base station with a service coverage area, and a number of cellular telephones (communications units, also sometimes referred to as mobile stations or MSs). The service coverage areas of adjacent cells are typically arranged to partially overlap in such a manner as to provide a substantially continuous coverage area in which a communications unit receiving service from one cell may be handed off to an adjacent cell with no interruption in service. The DECT European digital cellular system is an example of such a system.

[0003] The DECT system is a Time Division Multiple Access Time Division Duplex (TDM/TDD) system. In the DECT system the same frequency is used both for uplink (MS to base station) and downlink (base station to MS) communications in any one call, with each frequency being divided into time frames to facilitate duplex (both directions) communications.

[0004] In such radio communication systems, there is the potential for communications between adjacent frequencies, adjacent cells and in some cases adjacent time periods, to interfere with one another, thereby reducing the quality of the communication link. Since adjacent cell sites operate on different frequencies, and since the present sites are time multiplexed for those mobile stations operating at the same frequency, the possibility of interference between mobile stations is reduced.

[0005] Other cellular systems are Frequency Division Duplex systems where, instead of the transmissions being separated by time they are separated by frequency. In such systems interference issues between two geographically close mobile stations using FDD duplex mode are well known and have been addressed by the radio communications industry.

[0006] Two US patents dealing with handover between different systems have been identified and the following summarises their content:

US Patent no 5737703: 'Multi Mode Radio Telephone which Executes Handover Between Different Systems'. This Patent deals with a radio telephone capable of operating in more than one system, and so, comprising communications and control means associated with each of the radio systems. The call may be handed over from one system to another having the highest signal quality of the lowest cost. The handover is carried out by continuing the communication with initial network until communication with the second one is completely established. Moreover, audible effects due to potential vocoders differences are inhibited by an appropriate filtering. US Patent no 5659598: 'Dual Mode Subscriber Terminal and a Handover Procedure of the Dual Mode Subscriber Terminal in a Mobile Telecommunication Network'. This patent deals with the more precise situation of a dual mode mobile capable to operate both in a cordless telephone system and in a radio cellular system. It presents in particular a method for performing handover between systems with network-initiated handover and mobile-initiated handover. However, it should be noted that these patents do not address compatibility issues between two geographically close mobile stations operating with two different duplex technologies on the same system and possibly with the same base station.

[0007] Future systems, however, for example the proposed UMTS system in Europe will use both FDD and TDD duplexing technologies. New interference scenarios will arise and must be addressed, such as those where mobile stations (MSs) operating with different duplexing schemes are geographically close to each other.

Summary of the Invention

[0008] A method for reducing interference between a mobile station operating in time division duplex mode and a station operating in frequency division duplex mode comprising, scanning available frequency division duplex frequencies for a handover to a frequency division duplex system. If a frequency division duplex frequency is available, a handover is initiated to the frequency division duplex system.

[0009] In this manner, the risk of interference during handover between TDD and FDD modes is reduced.

Brief Description of the Drawings

[0010] FIG. 1 is a representation of an interference situation in which a mobile station operating in Time Division Duplex mode is interfered with by a mobile station operating in Frequency Division Duplex mode.

[0011] FIG. 2 shows an algorithm suitable for resolving the interference scenario of FIG. 1.

[0012] FIG. 3 is a representation of another interference situation in which an MS operating in Frequency Division Duplex mode is interfered with by and MS operating in Time Division Duplex mode.

[0013] FIG. 4 shows an algorithm suitable for resolving the interference scenario of FIG. 3.

Description of a Preferred Embodiment

[0014] In a system such as that described, in which both TDD and FDD duplexing modes are used, it is assumed the mobile stations (MSs) generally will have the

ability to operate alternatively in both modes. Two different interference scenarios involving one MS as a victim of another MS using a different duplex method are: a TDD MS interfered with by an FDD MS; or an FDD MS interfered with by a TDD MS. (Obviously, while the following is described in terms of two mobile stations, one station could be fixed or relatively fixed, with the MS approaching to cause the interfering activity.) A solution to each of these interference scenarios follows.

[0015] FIG. 1 is a representation of an interference situation in which a mobile station operating in Time Division Duplex mode is interfered with by a mobile station operating in Frequency Division Duplex mode.

[0016] The TDD MS 10 receives on frequency f1 and the FDD MS 12 transmits at frequency f2, which interferes with the TDD MS 10. For clarity, FIG. 1 shows two base stations, one base station 14 operating in TDD mode and the other base station 16 operating in FDD mode. It should be noted that the same approach applies in the case where there is one base station operating in both TDD and FDD modes.

[0017] The solution to this interference problem is to require the TDD MS 10 to handover to the FDD system, leading to the known interference scenario involving two FDD MSs. If the two MSs 10 and 12 belong to the same network, the victim MS 10 can make an attempt to access the same cell as its interferer. If they belong to different networks, the TDD MS 10 will search in priority another FDD candidate cell instead of trying another TDD cell.

[0018] FIG.2 shows an algorithm suitable for resolving the interference scenario of FIG. 1. The TDD MS 10 is interfered with on the downlink at 20. The interfered-with MS 10 scans the eligible FDD frequencies at 22 (eligible in this case meaning those frequencies which otherwise meet the criteria for handover set by the system such as signal quality, signal strength, etc.). The network or the MS, or both, will determine whether the MS 10 can handover to an FDD cell.

[0019] If a handover is not possible an intra TDD handover is requested at 24. If a handover to the FDD mode is possible, a handover request is made to the FDD mode at 26.

[0020] FIG. 3 is a representation of another interference situation in which an MS 30 operating in Frequency Division Duplex mode is interfered with by an MS 32 operating in Time Division Duplex mode. The FDD MS 30 receives on frequency f2. The TDD MS 32 transmits at frequency f1. Once again, for clarity two base stations are shown, but the same approach applies in the case where one base station operates in both FDD and TDD modes.

[0021] The solution to this interference problem is to require the TDD MS 32 to determine whether it is receiving an FDD uplink frequency at a level indicating that an FDD mobile is transmitting in its vicinity. In that case the TDD MS 32 is potentially interfering with the FDD MS 30 and the TDD MS 32 searches for an FDD cell to make a handover attempt, leading again to the known interference scenario between two FDD MSs. This handover will limit the risk of interference to other mobiles as well, since other TDD mobiles may be operating on the same or nearby TDD cells.

[0022] FIG. 4 shows an algorithm suitable for resolving the interference scenario of FIG. 3. The TDD MS 32 scans the FDD uplink frequencies at 4(). If an uplink frequency is being used at 42, the potential for interference exists and the TDD Ms scans the eligible FDD frequencies at 44 to determine whether a handover to an FDD cell is possible. If a handover to an FDD cell is possible, the handover is requested at 46.

[0023] If a handover to an FDD cell is not possible, the TDD MS 32 scans the list of eligible TDD frequencies at 48 as provided by the base station 36. If a frequency more remote to the potentially-interfered-with FDD frequency is found a handover request is made at 50. If a handover cannot be made the uplink scanning sequence 40 is begun again.

[0024] It is within the contemplation of the invention that other dual-mode communications systems could benefit from the inventive concept described hereinbefore, for example, if one or both modes of operation were time and frequency divided as occurs in Code Division Multiple Access (CDMA) systems.

[0025] Thus in both interference scenarios the TDD MS is required to take action to avoid or mitigate the interference. This is so since the potential for interference between two TDD MSs is remote, as they are temporally separated, ar.d because the solution to FDD-FDD interference is known.

[0026] Hence, a method of operating a communications system employing both time divided and frequency divided channels and operating modes is provided such that handover between the two operating modes reduces interference in the communications system. Furthermore, the operation of both communications units and communications infrastructure have been described, detailing such a handover technique.

Claims

1. A method for reducing interference between a mobile station (10) operating in time division duplex mode and a mobile station (12) operating in frequency division duplex mode, the method comprising the steps of:

   scanning (40) by the time division duplex station, available frequency division duplex frequencies for a handover to a frequency division duplex system, and

   initiating (46) if a frequency division duplex frequency is available, a handover to the frequency division duplex system.

2. A method as set forth in claim 1 wherein:

   if no frequency division duplex frequency is available, scanning (48) time division duplex frequencies more remote from the interfered with frequency division duplex frequency; and

   if a more remote time division duplex frequency is available, initiating (50) a handover to the more remote time division duplex system.

3. A communication system providing communication channels and providing to a plurality of mobile stations communicating on the communication systems at least two operating modes including a first time division duplex operating mode and a second frequency division duplex operating mode, wherein a mobile station (10, 12) operating in the first or second operating mode is capable of scanning the alternative operating mode and initiating a handover to the alternative operating mode if the mobile station is suffering interference on its existing operating mode.

4. A mobile station capable (10, 12) of operating in both a time division duplex mode and a frequency division duplex mode, the mobile station comprising scanning means for scanning communications channels on an alternative operating mode when communication on a channel in an existing mode is suffering from interference.

5. A mobile station (10, 12) according to claim 4, further comprising initiating means to initiate handover to a communication system providing the alternative operating mode when communications on the existing mode are suffering interference.

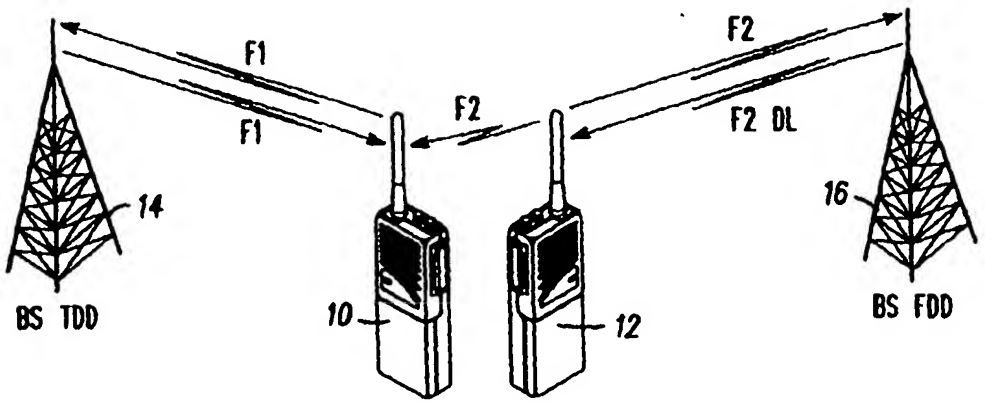
F1
F1
F2
F2
F2 DL
14
16
BS TDD
BS FDD
10
12

FIG. 1

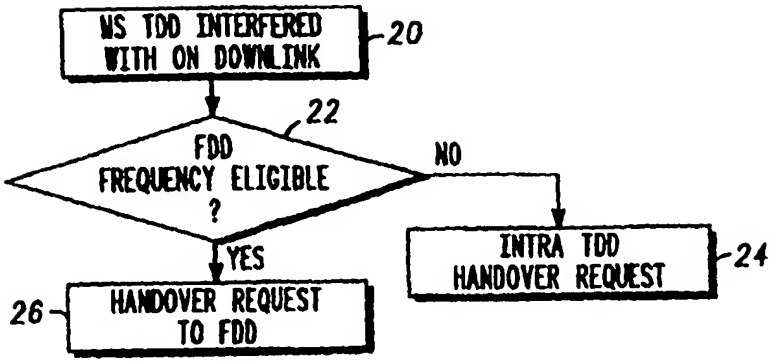
MS TDD INTERFERED WITH ON DOWNLINK
20
22
FDD FREQUENCY ELIGIBLE ?
NO
YES
INTRA TDD HANDOVER REQUEST
24
HANDOVER REQUEST TO FDD
26

FIG. 2

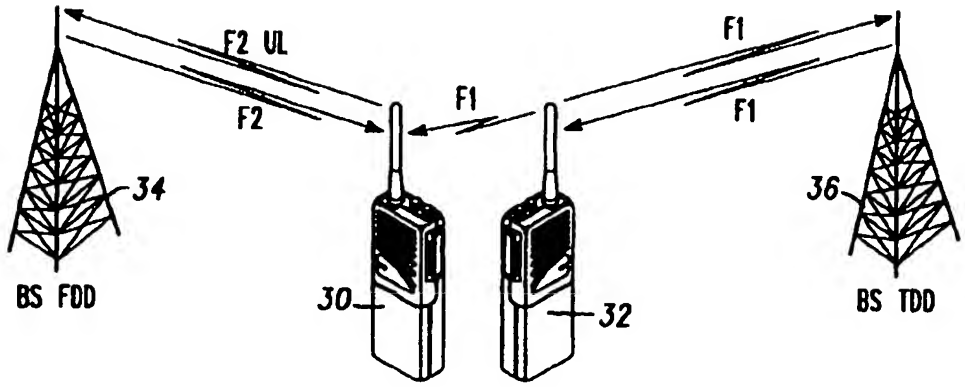
F2 UL
F2
F1
F1
F1
34
36
BS FDD
BS TDD
30
32

FIG. 3

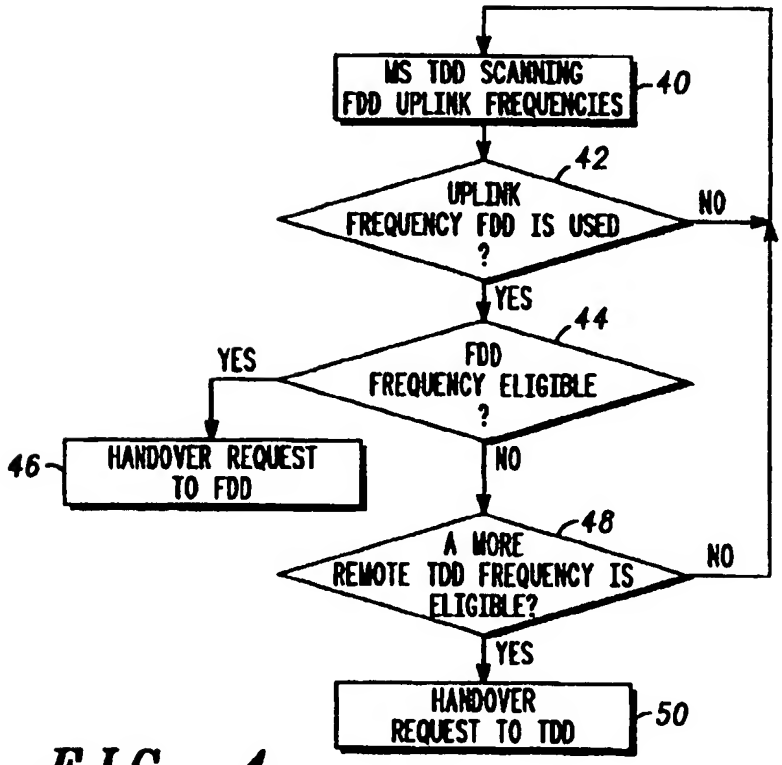
MS TDD SCANNING FDD UPLINK FREQUENCIES
40
42
UPLINK FREQUENCY FDD IS USED ?
NO
YES
44
FDD FREQUENCY ELIGIBLE ?
YES
46
HANDOVER REQUEST TO FDD
NO
48
A MORE REMOTE TDD FREQUENCY IS ELIGIBLE?
NO
YES
HANDOVER REQUEST TO TDD
50

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 40 2029

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	WO 96 38997 A (HONG KONG TELECOM CSL LTD ;LUI YING CHUN (GB)) 5 December 1996 (1996-12-05) * page 3, line 6 - line 20 * * page 9, line 19 - page 11, line 9 *	1-5	H04Q7/38
Y	WO 98 48585 A (NOKIA TELECOMMUNICATIONS OY ;KONTIO ARI (FI); KORHONEN JUHA O (GB)) 29 October 1998 (1998-10-29) * page 3, line 17 - line 27 * * page 10, line 3 - line 23 *	1-5	
A	EP 0 492 800 A (NORTHERN TELECOM LTD) 1 July 1992 (1992-07-01) * page 2, column 2, line 8 - line 18 *	1-5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	14 January 2000	Bernedo Azpiri, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 40 2029

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-01-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9638997 A	05-12-1996	AU 701840 B	04-02-1999
		AU 5829096 A	18-12-1996
		CN 1191660 A	26-08-1998
		EP 0829179 A	18-03-1998
WO 9848585 A	29-10-1998	FI 971717 A	23-10-1998
		AU 7045298 A	13-11-1998
		ZA 9803332 A	26-10-1998
EP 0492800 A	01-07-1992	CA 2031551 A	06-06-1992
		DE 69125466 D	07-05-1997
		DE 69125466 T	17-07-1997
		US 5239682 A	24-08-1993

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82